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H1Q QJE QKA

(56) Documents Cited
GB 2216726 A US 4367474 A US 4053895 A

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UK CL (Edition O) H1Q QJE QKA
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(54) Planar antenna and radio apparatus comprising the same

(57) A planar antenna comprises a ground plate 102 and a conductive plate 101 arranged in parallel. The conductive plate 101 has a ground terminal 104, a feed terminal 105 and means 107 - 109 of forming a further ground connection terminal arranged such that it will change the resonant frequency of the antenna. Each of the terminals is arranged at separate positions. A dielectric spacer 103 may be located between the plates 101, 102. The plates may be formed by metal deposited and etched on either surface of a dielectric substrate. The terminals may be L-shaped with the ground terminal 104 located between the other terminals with the distance between the terminals being equal to or less than one third of the circumference of the conductive plate. There may be one or more means of forming a further ground connection which may include a relay, diode or transistor switch. The antenna my be used in radio apparatus.

FIG.1A

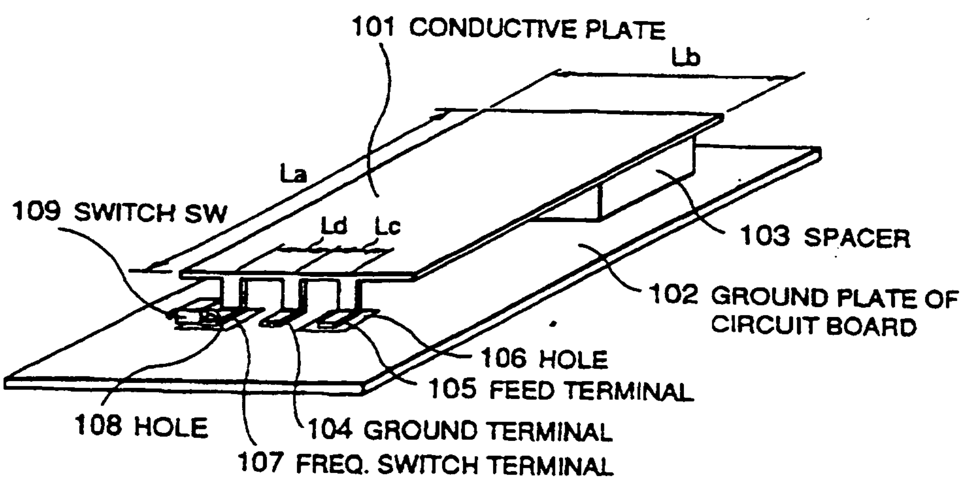

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FIG.1A

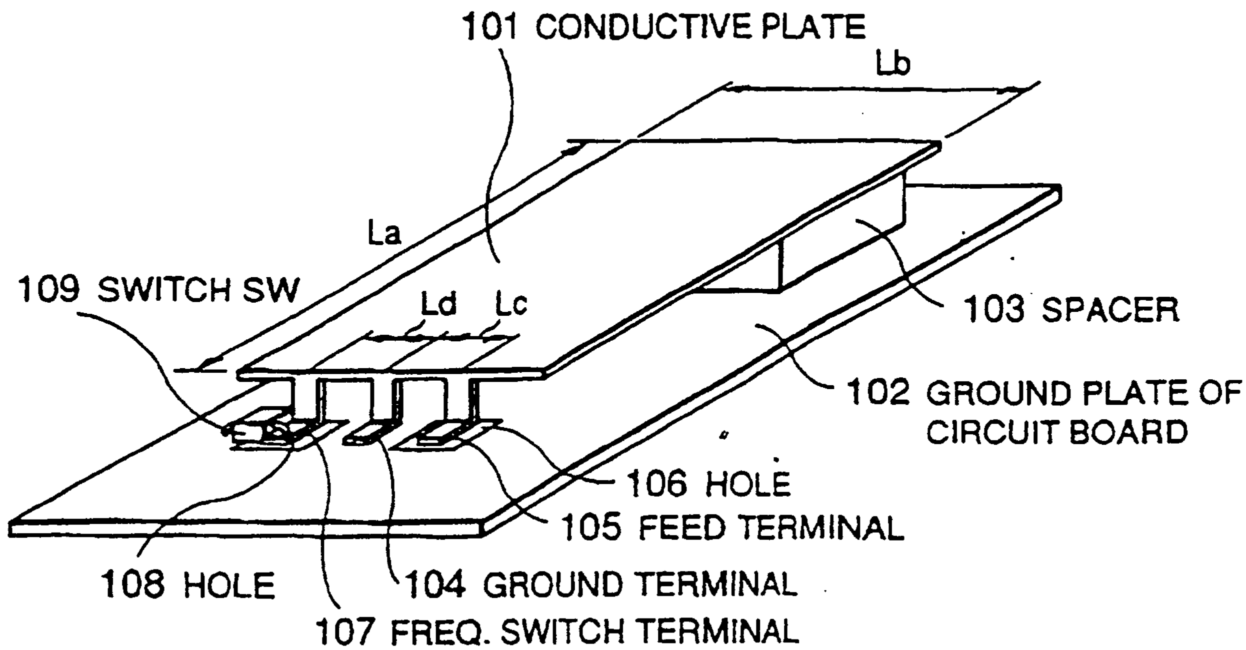

101 CONDUCTIVE PLATE
Lb
La
109 SWITCH SW
Ld
Lc
103 SPACER
102 GROUND PLATE OF CIRCUIT BOARD
106 HOLE
105 FEED TERMINAL
108 HOLE
104 GROUND TERMINAL
107 FREQ. SWITCH TERMINAL

FIG.1B

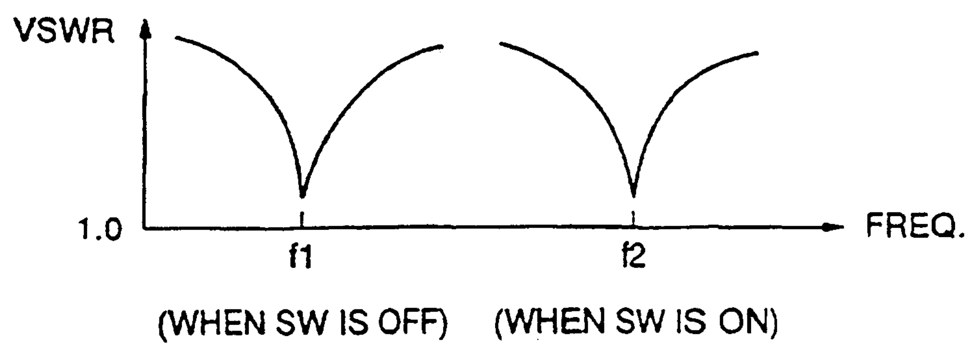

VSWR
1.0
FREQ.
f1
f2
(WHEN SW IS OFF)
(WHEN SW IS ON)

FIG.2

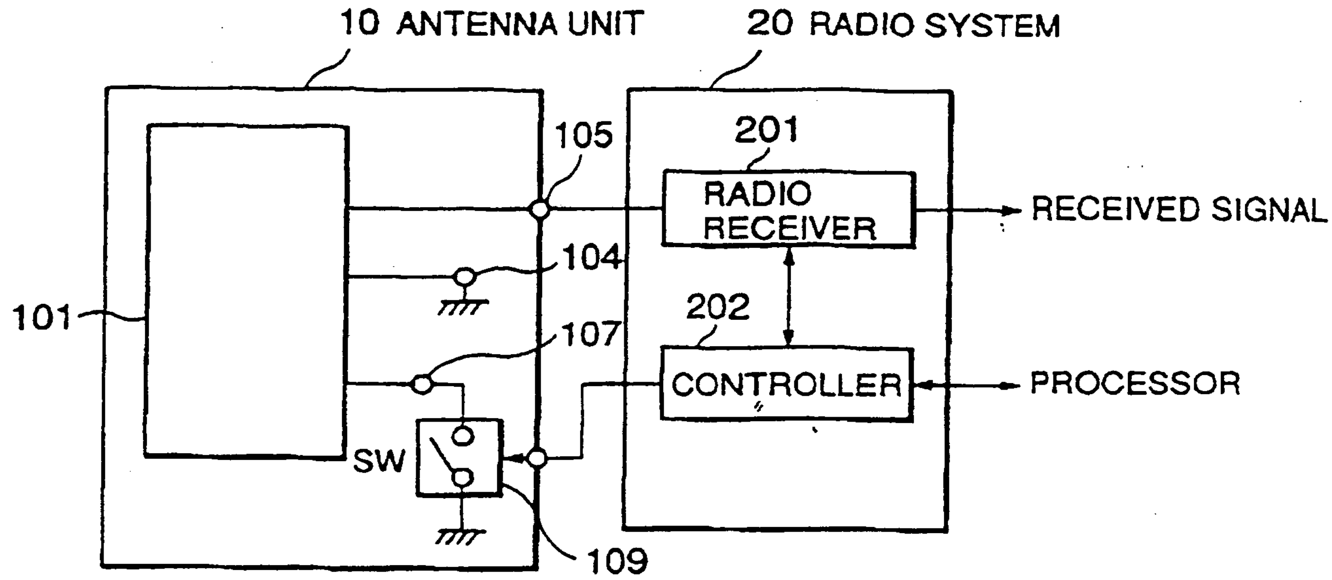
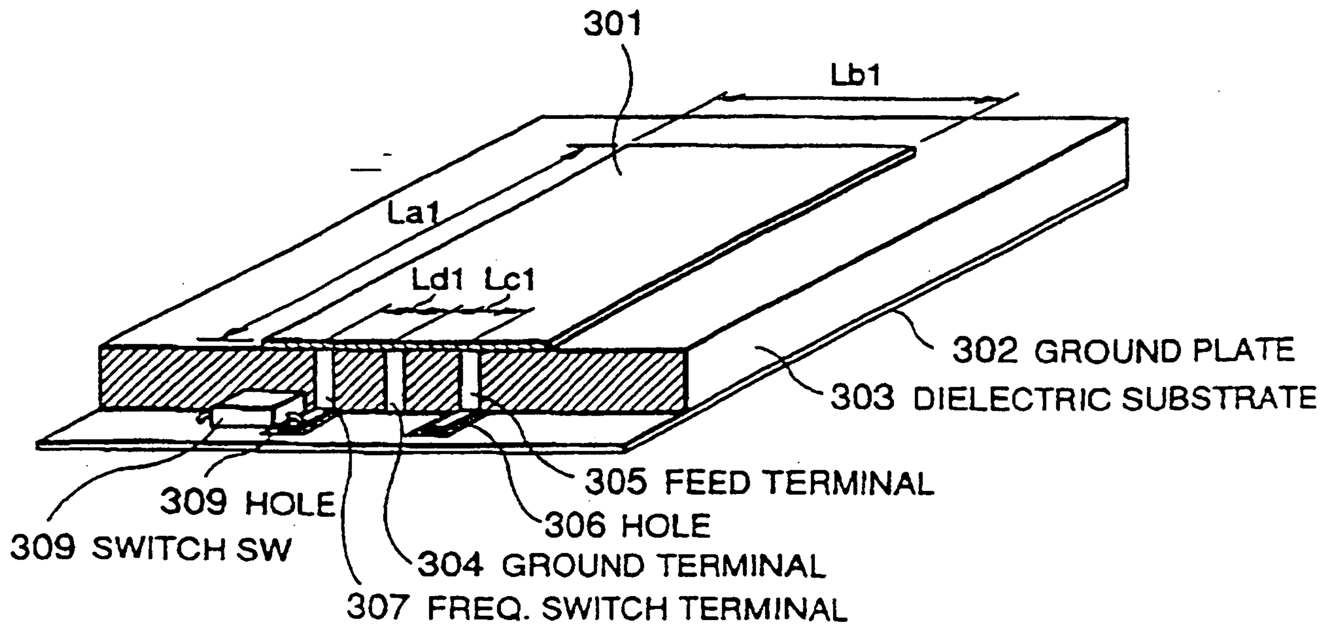

10 ANTENNA UNIT
20 RADIO SYSTEM
105
201
RADIO RECEIVER
RECEIVED SIGNAL
104
101
202
107
CONTROLLER
PROCESSOR
SW
109

FIG.3


301
Lb1
La1
Ld1
Lc1
302 GROUND PLATE
303 DIELECTRIC SUBSTRATE
305 FEED TERMINAL
309 HOLE
306 HOLE
309 SWITCH SW
304 GROUND TERMINAL
307 FREQ. SWITCH TERMINAL

PLANAR ANTENNA AND RADIO APPARATUS COMPRISING THE SAME

The present invention relates to a planar antenna and apparatus comprising the same, and in particular to an improvement of a planar antenna for radio apparatuses such as digital mobile telephones and other portable radio transceivers.

A planar inverted-F antenna which can be miniaturized has been widely used in mobile communication apparatuses such as portable radio telephones. Since the frequency range which provides acceptable antenna gains is relatively narrow (generally, 4-5%), however, there have been proposed several antenna structures which can be used in a plurality of frequency bands or a wider frequency range. In an example of conventional antennas, two antennas having different resonance frequencies are used to provide two usable frequency bands. In another antenna, the volume of a element is doubled to substantially widen the frequency range.

Further, a patch antenna has been disclosed in Japanese Patent Unexamined publication No. 62-188504. This conventional antenna is provided with an adjuster for connecting two radiation

elements or adjusting the amount of overlapped areas of the two radiation elements to achi ve a wider frequency range where acceptable antenna gains are obtained.

However, the above conventional antennas need a plurality of radiation elements or the doubled volume of a radiation element. Such a large element cannot be suitable for mobile apparatuses such as portable telephones. On the other hand, the patch antenna needs a mechanical means for moving the radiation elements. Therefore, it is difficult to obtain a stable antenna characteristic and rapid switching of antenna frequency bands. Further, since the large amount of energy is required to move the radiation elements, the power consumption of a portable telephone is increased.

An object of at least the preferred embodiments of the present invention is to provide a small-sized planar antenna which can achieve a wide usable frequency range.

Another such object is to provide a small-sized planar antenna which can rapidly select one of a plurality of resonance frequencies with reliability.

Still another such object is to provide a radio apparatus which uses a small-sized planar inverted-F antenna to rapidly select one of a plurality of frequency channels

with reliability.

Accordingly, the present invention provides a planar antenna comprising a ground plate, a conductive plate facing the ground plate, the conductive plate having a ground terminal at a first position thereof and having a feed terminal at a second position spaced from the first position, and means for changing a resonant frequency of the antenna by electrically connecting the conductive plate to the ground plate at a third position which is spaced from the first and second positions.

According to a preferred embodiment of the present invention, an antenna resonance frequency is changed by increasing the number of electrical connections of a conductive plate to the ground plate at predetermined positions of the conductive plate. In other words, the planar antenna includes a ground plate and a conductive plate arranged in parallel to the ground plate. The conductive plate has a ground terminal at a first position thereof and has a feed terminal at a second position thereof which is different from the first position. The planar antenna is provided with a frequency changer which changes the antenna resonance frequency by electrically connecting the conductive plate to the ground plate at a third position which is different from the first and second positions.

Therefore, a wider frequency range can be obtained without the conductive plate increasing in area or volume. In the case where the planar antenna is employed in a radio apparatus such as a portable telephone, the radio apparatus can widely change in receiving frequency by the frequency changer. Therefore, it is suitable for a radio communications system in which a plurality of frequency channels in a wide frequency range are selectively changed.

Accordingly, in a second aspect the present invention provides radio apparatus comprising a planar antenna as described above, a radio system connected to the feed terminal of the antenna, and a controller for controlling reception of a radio signal by the apparatus.

Preferred features of the present invention will now be described, purely by way of example only, with reference to the accompanying drawings, in which:–

Fig. 1A is a perspective view showing a planar inverted-F antenna according to a first embodiment;

Fig. 1B is a diagram showing a frequency response of voltage standing wave ratio (VSWR) of the planar inverted-F antenna;

Fig. 2 is a schematic block diagram showing the radio section of a radio apparatus using the antenna unit;

and

Fig. 3 is a perspective view partly in section, showing a planar inverted-F antenna according to a second embodiment.

Referring to Fig. 1A, there is shown a planar inverted-F antenna having a conductive plate (or a radiation element) 101 which receives radio waves. The conductive plate 101 has a rectangular shape of La×Lb and faces a ground plate 102 substantially parallel thereto. The plates are separated by a spacer 103 made of dielectric. In the case of a portable telephone, the ground plate 102 may be the conducting box of the portable telephone.

The conductive plate 101 is provided with a ground terminal

104 at a predetermined position on a shorter side of the rectangular conductive plate 101. The ground terminal 104 is bent at a right angle to the conductive plate 101 and then the end portion of the ground terminal 104 is further bent at a right angle to form a contact portion parallel to the ground plate 102. The contact portion of the ground terminal 104 is fixed to the ground plate 102 by soldering or the like. Therefore, the conductive plate 101 is stably supported by the spacer 103 and the ground terminal 104.

On the side of the rectangular conductive plate 101, a feed terminal 105 is formed at a distance of Lc from the ground terminal 104. The feed terminal 105 is similarly bent to form a contact portion parallel to the ground plate 102. The contact portion of the feed terminal 105 is electrically connected to a radio receiver (not shown) through a hole 106 formed in the ground plate 102. The hole 106 is designed to prevent contact between the feed terminal 105 and the ground plate 102. The distance Lc is determined so as to match the impedance of the feed terminal 105 to the input impedance of the radio receiver. Needless to say, the position of the feed terminal 105 is not limited to on one side of the conductive plate 101. It may be provided at a position within the plane of the conductive plate 101.

The conductive plate 101 is further provided with a frequency switch terminal 107 which is formed at a distance of Ld from the ground terminal 104 and on the opposite side of the ground terminal to the feed terminal 105. The frequency switch terminal 107 is similarly

bent to form a contact portion parallel to the ground plate 102 in which a hole 108 is formed at the position of the contact portion of the frequency switch terminal 107. The contact portion of the frequency switch terminal 107 is connected to the ground plate 102 through a switch 109 which is controlled by a controller. Therefore, when the switch 109 is closed or on, the frequency switch terminal 107 is electrically connected to the ground plate 102 and, when open or off, it is disconnected from the ground plate 102.

The switch 109 is preferably a small-sized switch so as to connect the frequency switch terminal 107 to the ground plate 102 without adding impedance. For example, a reed relay and a small switch mounted in a TO-5 case or the like may be used. Further, in the case where rapid switching is needed, a semiconductor switching device such as a PIN diode switch and a transistor switch may be used.

Referring to Fig. 1B, there is shown a frequency response of the planar inverted-F antenna of Fig. 1A depending on whether the switch 109 is on or off. When the switch 109 is off, an equivalent length L of the circumference of the conductive plate 101 is represented by L=2La+2Lb. In this case, the voltage standing wave ratio (VSWR) is minimized when f=f1. In other words, f1 is a first antenna resonance frequency. When the switch 109 is on, the frequency switch terminal 107 is also grounded through the switch 109, resulting in a reduced equivalent length L=2La+2Lb-Ld. In this case, the VSWR is minimized when f=f2. The

frequency f2 is a second antenna resonance frequency which is higher than the f1 depending on the distance Ld.

Therefore, the longer the distance Ld, the higher the second antenna resonance frequency f2. However, as the distance Ld becomes larger, the radiation pattern of the antenna is deteriorated. Therefore, it is preferable that the distance Ld between the ground terminal 104 and the frequency switch terminal 107 is equal to or less than one third the circumference of the conductive plate 101.

As described above, the antenna resonance can be made at two frequency bands f1 and f2 by controlling the switch 109. Therefore, a wider frequency range can be obtained without the conductive plate 101 increasing in area or volume. In the case where more than two switches 109 are connected at different positions, the antenna resonance is obtained at a plurality of frequency bands, allowing fine changing in antenna resonance frequency. Further, since the on/off control of the switch 109 changes the antenna resonance frequency, rapid frequency changing can be performed with relatively low power consumption and with reliability.

The planar inverted-F antenna as shown in Fig. 1A can be employed in a portable telephone terminal used in a communications system using a plurality of frequency channels such as a TDMA (time division multiple access) mobile communications system where a plurality of predetermined frequency channels are selectively received.

Referring to Fig. 2, there is shown a radio apparatus such as a portable telephone which is provided with the planar inverted-F antenna. The radio apparatus is comprised of an antenna unit 10 and a radio system 20. The antenna unit 10 includes the planar inverted-F antenna as shown in Fig. 1A and the radio system 20 includes a radio transmitter (not shown), a radio receiver 201 and a controller 202. The radio receiver 201 receives a radio-frequency signal from the conductive plate 101 of the antenna unit 10 through the feed terminal 105 and then performs frequency-conversion and demodulation to produce a received signal. A processor (not shown) receives the received signal to inform a user of received data through man-machine interface (not shown).

The controller 202 controls the radio receiver 201 and the radio transmitter, and further controls the switch 109 of the antenna unit 10. More specifically, as described before, when the antenna resonance frequency is set to f1, the controller 202 turns the switch 109 off. On the other hand, when the antenna resonance frequency is set to f2, the controller 202 turns the switch 109 on. In this manner, the radio apparatus can widely change in receiving frequency by switching the switch 109 of the antenna unit 10. Therefore, it is suitable for a radio communications system in which a plurality of frequency channels in a wide frequency range are selectively changed.

Referring to Fig. 3, there is shown a second embodiment of a planar inverted-F antenna.

The planar inverted-F antenna has a conductive plate (or a radiation element) 301 and a ground plate 302 formed on the respective surfaces of a dielectric substrate 303 made of insulating material such as Teflon. The conductive plate 301 has a rectangular shape of $La_1 \times Lb_1$. More specifically, the conductive plate 301 and the ground plate 302 are formed by etching metal plates such as copper on the surfaces of the dielectric substrate 303, respectively.

The conductive plate 301 is electrically connected to the ground plate 302 through a ground terminal 304 at a predetermined position on a shorter side of the rectangular conductive plate 301. The ground terminal 304 is formed by a through-hole of the dielectric substrate 303. On the side of the rectangular conductive plate 301, a feed terminal 305 is formed at a distance of Lc_1 from the ground terminal 304. The feed terminal 305 electrically connects the conductive plate 301 to a radio receiver (not shown) through a hole 306 formed in the ground plate 302. The hole 306 is designed to prevent contact between the feed terminal 305 and the ground plate 302. The distance Lc_1 is determined so as to match the impedance of the feed terminal 305 to the input impedance of the radio receiver. Needless to say, the position of the feed terminal 305 is not limited to on one side of the conductive plate 301. It may be provided at a position within the plane of the conductiv plate 301.

The conductive plate 301 is further provided with a frequency switch terminal 307 which is formed at a distance of

Ld_1 from the ground terminal 304 and on the opposite side of the ground terminal 304 to the feed terminal 305. The ground plate 302 has a hole 308 formed at the position of the end portion of the frequency switch terminal 307 so that the frequency switch terminal 307 is not in contact with the ground plate 302. The frequency switch terminal 307 is connected to the ground plate 302 through a switch 309 which is controlled by a controller. Therefore, when the switch 309 is closed or on, the frequency switch terminal 307 is electrically connected to the ground plate 302 and, when open or off, it is disconnected from the ground plate 302.

As described in the first embodiment, it is also preferable that the distance Ld_1 between the ground terminal 304 and the frequency switch terminal 307 is equal to or less than one third the circumference of the conductive plate 301. In the second embodiment, more than two frequency switch terminals may be formed to achieve fine frequency changing. Since the operation of the second embodiment is similar to that of the first embodiment as shown in Fig. 1A, the description of its operation is omitted.

According to the second embodiment as shown in Fig. 3, since the dielectric substrate 303 is sandwiched between the conductive plate 301 and the ground plate 302, the conductive plate 301 reduces in size depending on the dielectric constant ε_r of the dielectric substrate 303. More specifically, when the switch 309 is off, an equivalent length L of the circumference of the conductive plate 301 is represented by $L=2La_1+2Lb_1$. Therefore, the antenna resonance frequency f1 is a frequency which

approximately satisfies the following equation:

$$2La_1 + 2Lb_1 = \lambda/2\ \varepsilon_r^{1/2},$$

where λ is a wave length corresponding to the antenna resonance frequency f1. Therefore, the size of the conductive plate 301 is smaller than that of the conductive plate 101 of Fig. 1A by $\varepsilon_r^{1/2}$. Further, the dielectric substrate 303 stably supports the conductive plate 301 and the ground plate 302, resulting in stable antenna radiation characteristic.

According to the first and second embodiments, the ground terminal, the feed terminal and the frequency switch terminal are connected to the side of the conductive plate. However, these connection positions are not limited to them. They may be provided at positions within the plane of the conductive plate.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.

A planar antenna includes a ground plate and a conductive plate arranged in parallel to the ground plate. The conductive plate has a ground terminal at a first position thereof and has a feed terminal at a second position thereof. The planar antenna further includes a frequency change switch which is used to change the antenna resonance frequency by electrically connecting the conductive plate to the ground plate at a third position which is different from the first and second positions.

CLAIMS

1. A planar antenna comprising:

a ground plate;

a conductive plate facing the ground plate, the conductive plate having a ground terminal at a first position thereof and having a feed terminal at a second position spaced from the first position; and

means for changing a resonant frequency of the antenna by electrically connecting the conductive plate to the ground plate at a third position which is spaced from the first and second positions.

2. A planar antenna according to Claim 1, further comprising a dielectric spacer sandwiched between the ground plate and the conductive plate.

3. A planar antenna according to Claim 1, wherein the ground plate and the conductive plate are formed on surfaces of a dielectric substrate by etching metal plates on respective sides of the dielectric substrate.

4. A planar antenna according to any preceding claim, wherein the first position lies between the second and third positions.

5. A planar antenna according to any preceding claim, wherein a distance between the first position and the third position is equal to or smaller than one third of the circumference of the conductive plate.

6. A planar antenna according to any preceding claim, wherein the position of the third position is variable.

7. A planar antenna according to any of Claims 1 to 5, wherein the frequency changing means comprises:

an L–shaped terminal connected to the conductive plate and extending towards

the ground plate; and

means for selectively electrically connecting the conductive plate to the ground plate at the third position.

8. A planar antenna according to Claim 6, wherein the frequency changing means comprises:

a plurality of L-shaped terminals each connected to and spaced along the conductive plate and extending towards the ground plate; and

means for selectively electrically connecting the conductive plate to the ground plate at each of the third positions.

9. A planar antenna according to Claim 7 or 8, wherein the connecting means comprises one of a reed relay, a PIN diode switch and a transistor switch.

10. Radio apparatus comprising:

a planar antenna according to any preceding claim;

a radio system connected to the feed terminal of the antenna; and

a controller for controlling reception of a radio signal by the apparatus.

11. Radio apparatus according to Claim 10, wherein the controller is operable to control the frequency changing means.

12. Radio apparatus according to Claim 10 or 11, wherein the frequency of the signal to be received by the apparatus is one of a plurality of frequencies of signals which are receivable by the apparatus, and wherein the frequency changing means is connectable at a plurality of positions from which the third position is selectable, the second position and the third positions corresponding to said frequencies.

13. A planar antenna substantially as herein described with reference to and as shown in Figure 1A or Figure 3 of the accompanying drawings.

14. Radio apparatus substantially as herein described with reference to and as shown in Figure 2 of the accompanying drawings.

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Application No: GB 9717802.4
Claims searched: 1 - 14

Examiner: J. A. Watt
Date of search: 6 November 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H1Q (QJE, QKA)

Int Cl (Ed.6): H01Q 1/38, 9/04

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2216726 A	(KOKUSAI ELECTRIC) see fig.5b and page 1, lines 1 & 2	10 at least
X, Y	US 4367474	(U S ARMY) see figs.1 - 11 and col.2, lines 48 - 67	X: 1 - 3 at least Y: 10 at least
A	US 4053895	(U S AIR FORCE) see figs.1 - 8 and col.2, lines 29 - 68	1 at least

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Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
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